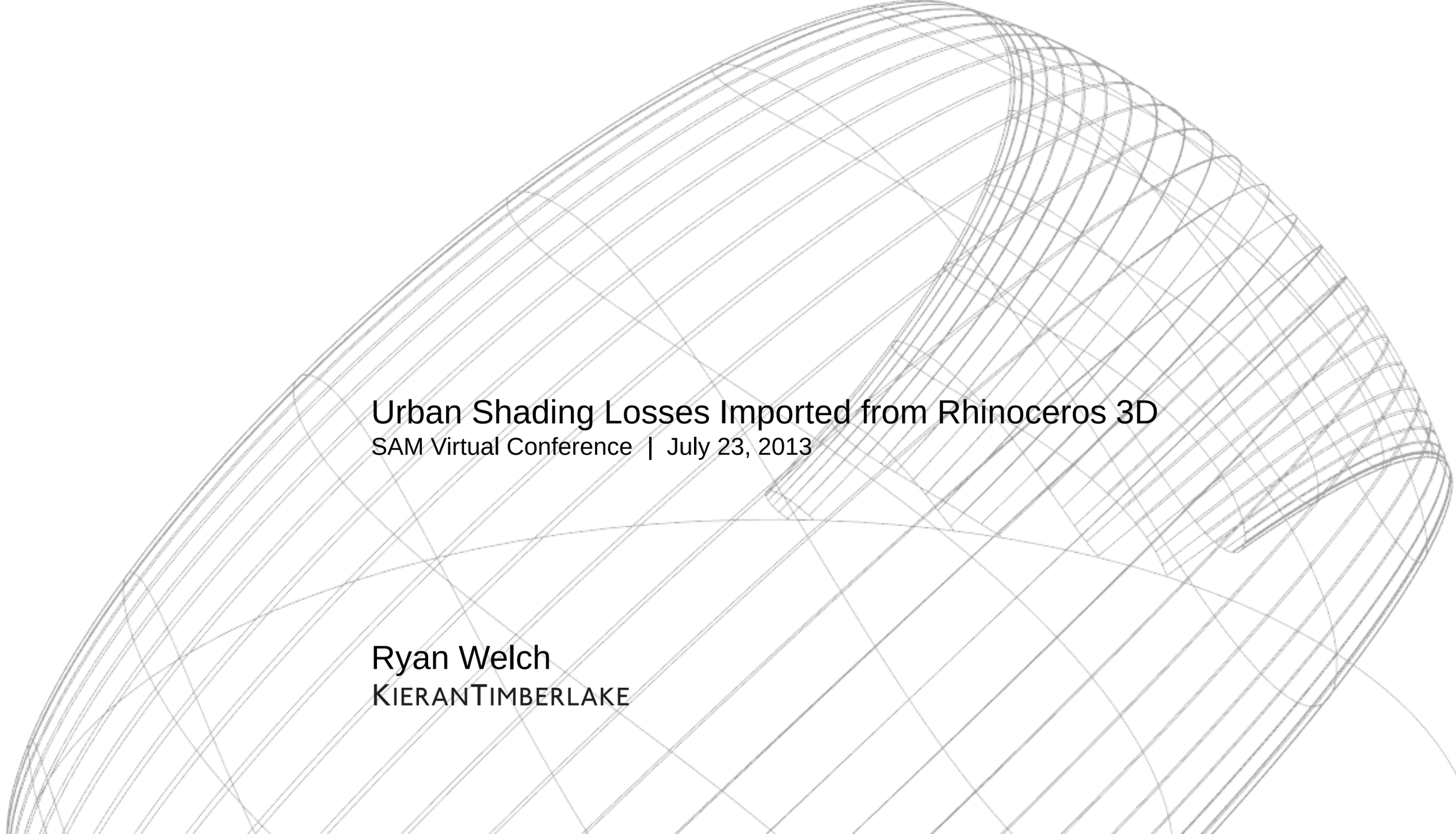


Urban Shading Losses Imported from Rhinoceros 3D

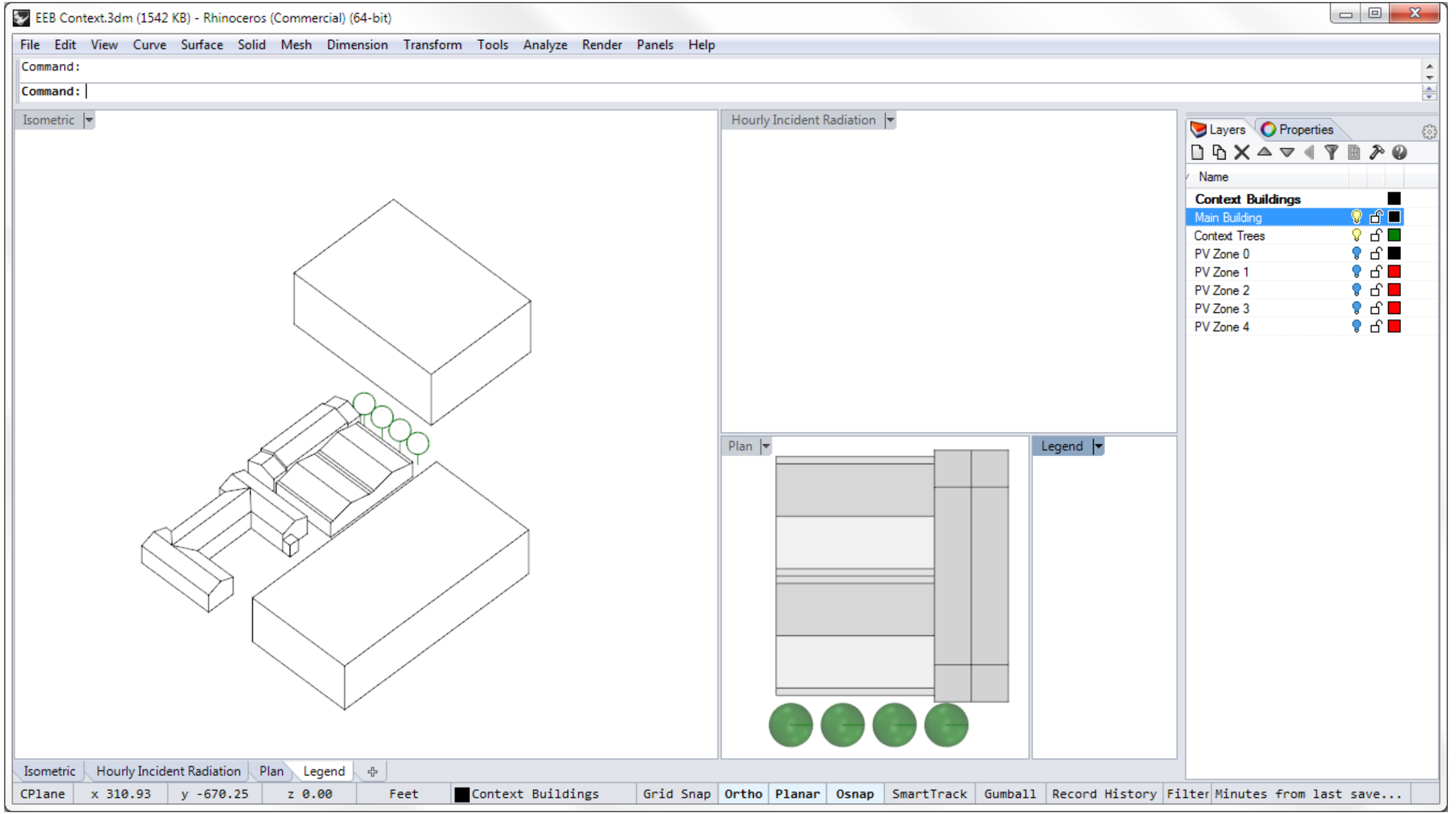
SAM Virtual Conference | July 23, 2013

Ryan Welch
KIERANTIMBERLAKE

Urban Shading Losses Imported from Rhinoceros 3D

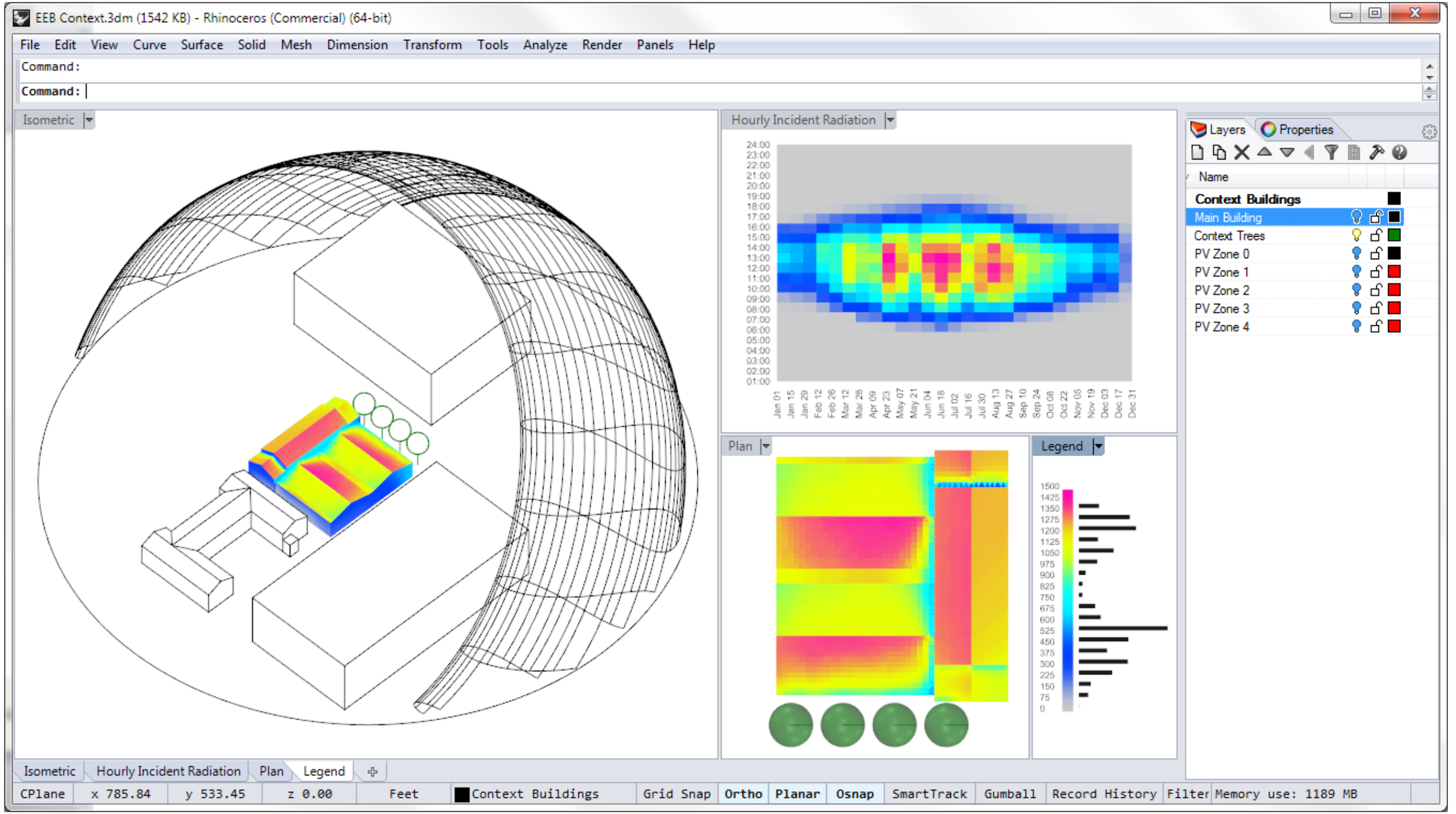
Building Context

 | July 23, 2013



Urban Shading Losses Imported from Rhinoceros 3D

Rhinoceros 3D Massing Model



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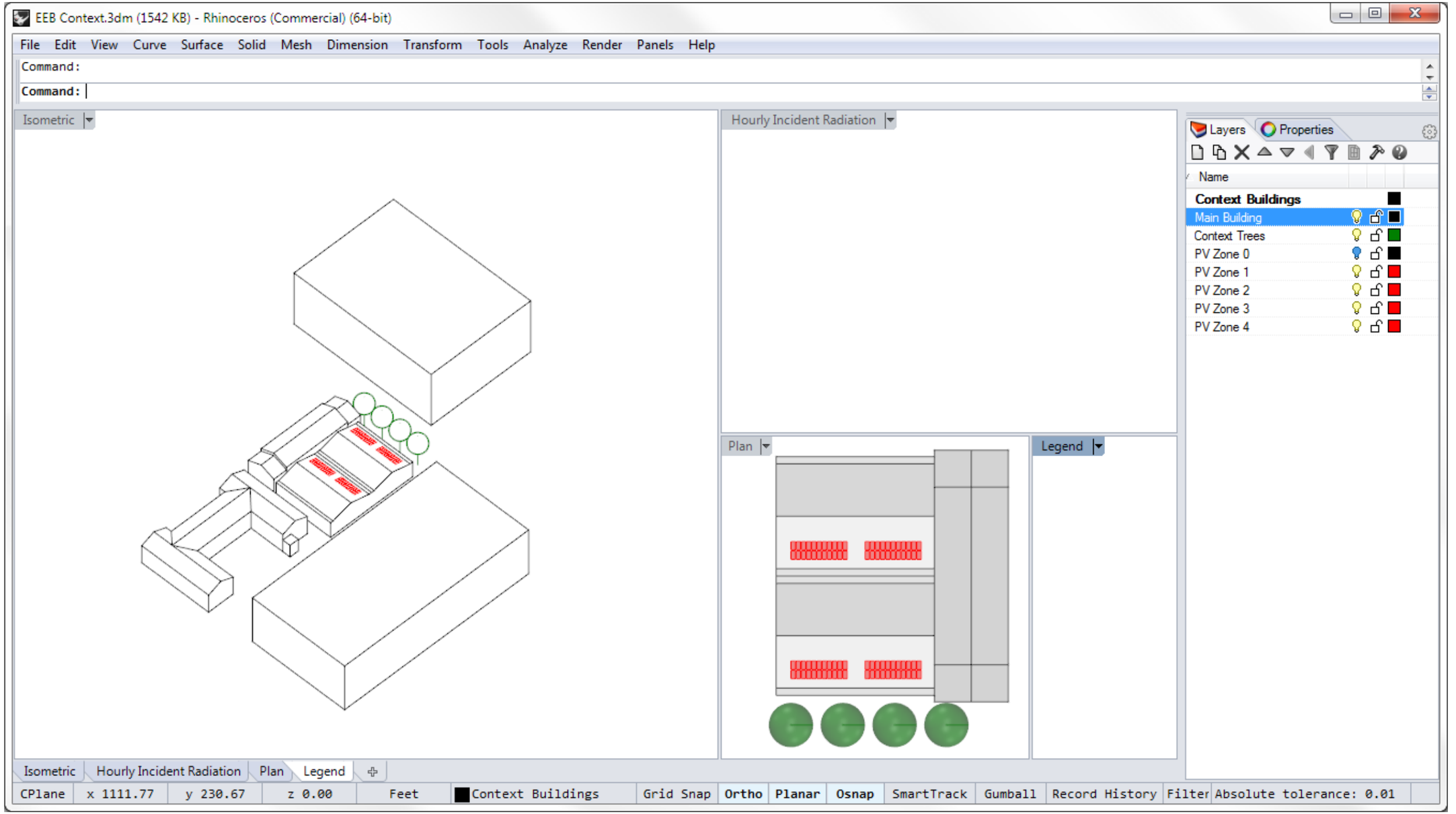
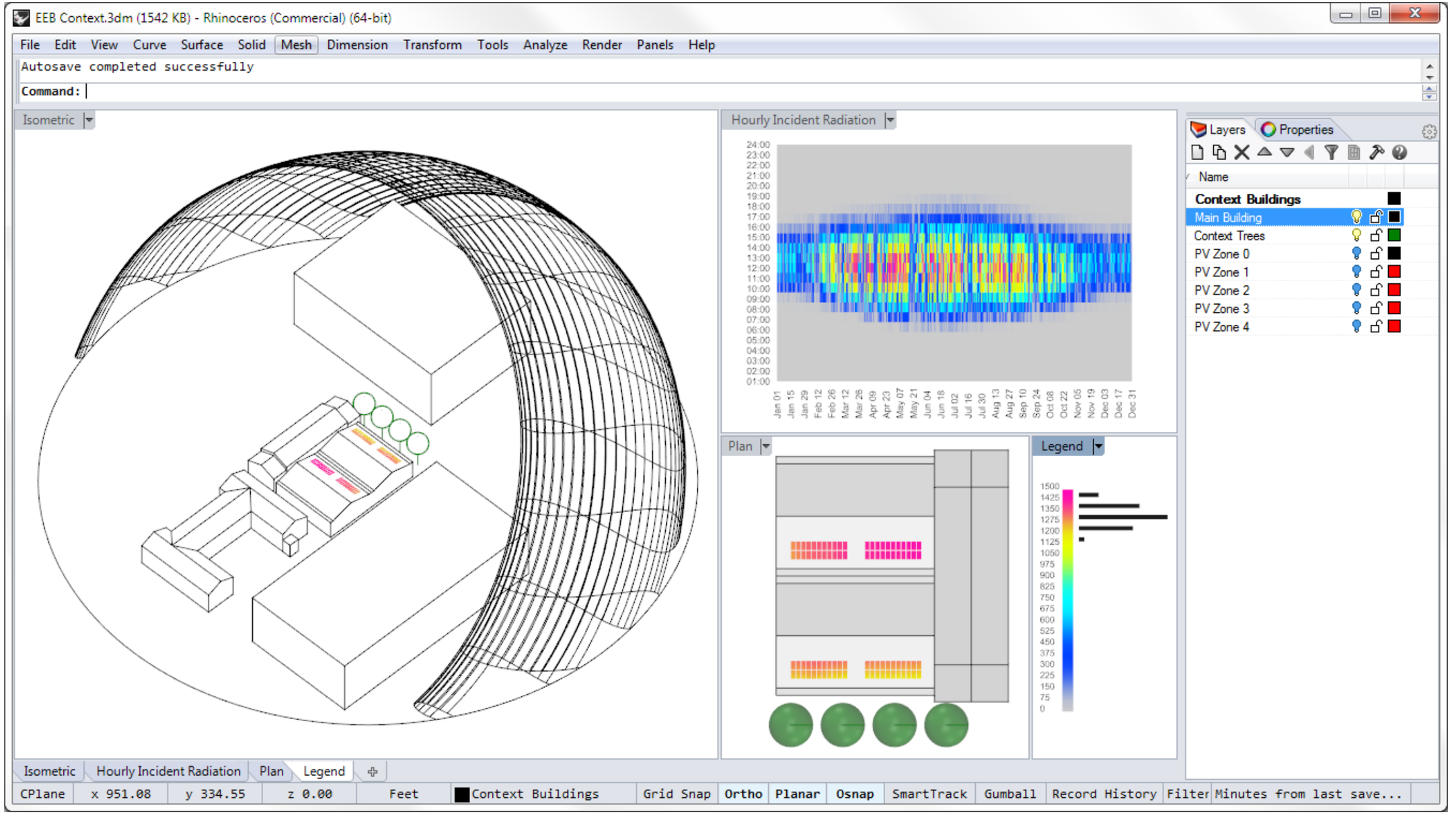
Incident Solar Radiation Study



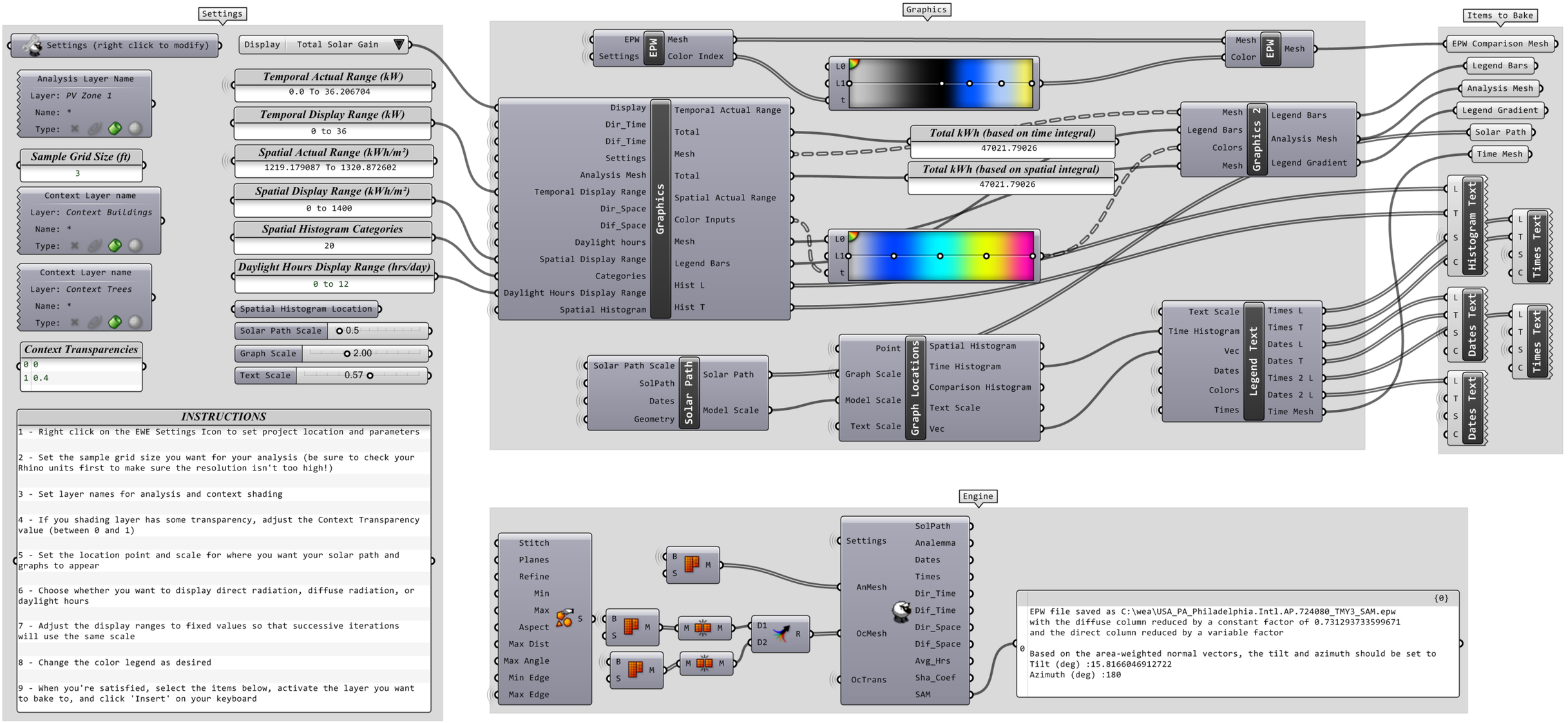
Urban Shading Losses Imported from Rhinoceros 3D

Potential PV Zones



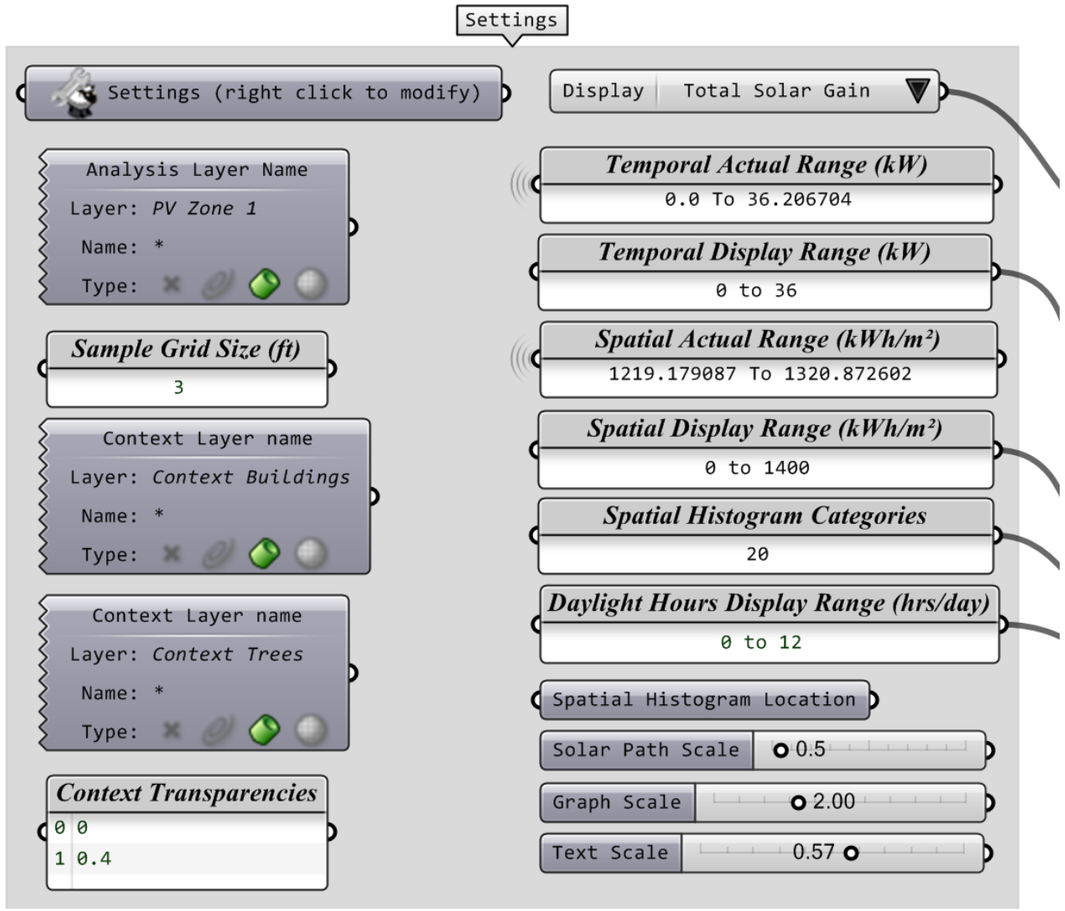
Urban Shading Losses Imported from Rhinoceros 3D

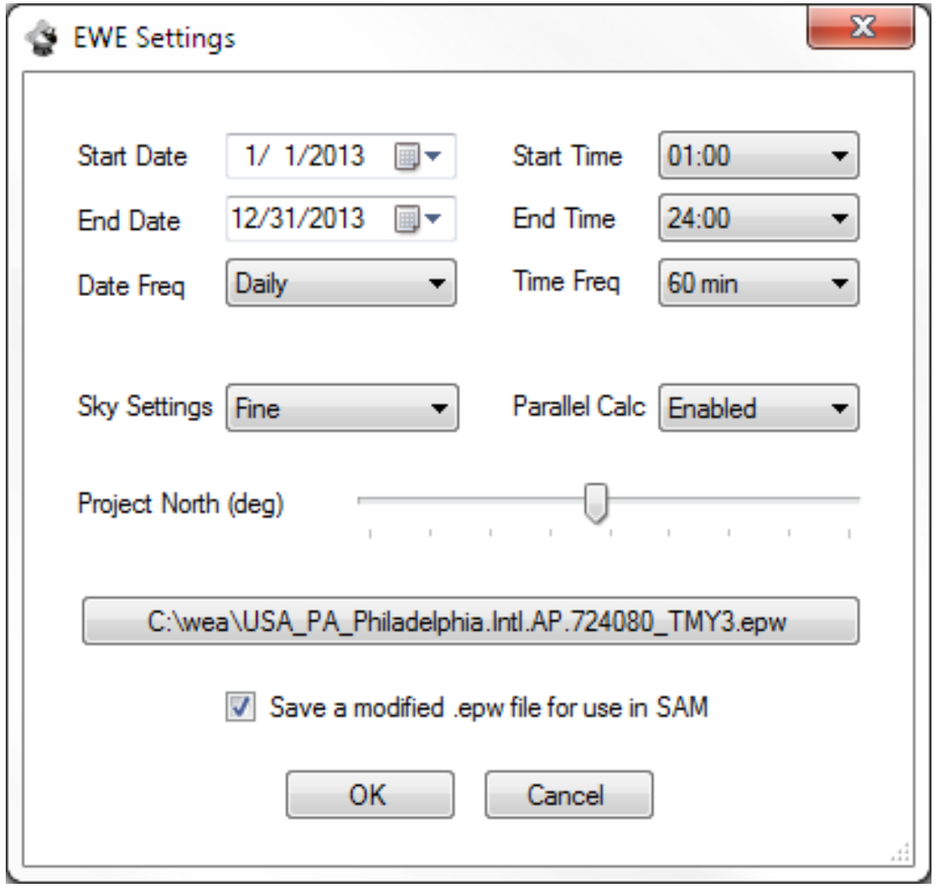
Available Incident Solar Radiation



Urban Shading Losses Imported from Rhinoceros 3D

Grasshopper Definition





Technical Report

Revised January 2008 • NREL/TP-560-34302

Solar Position Algorithm for Solar Radiation Applications

Ibrahim Reda and Afshin Andreas

NREL
National Renewable Energy Laboratory
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Golden, Colorado 80401-3393
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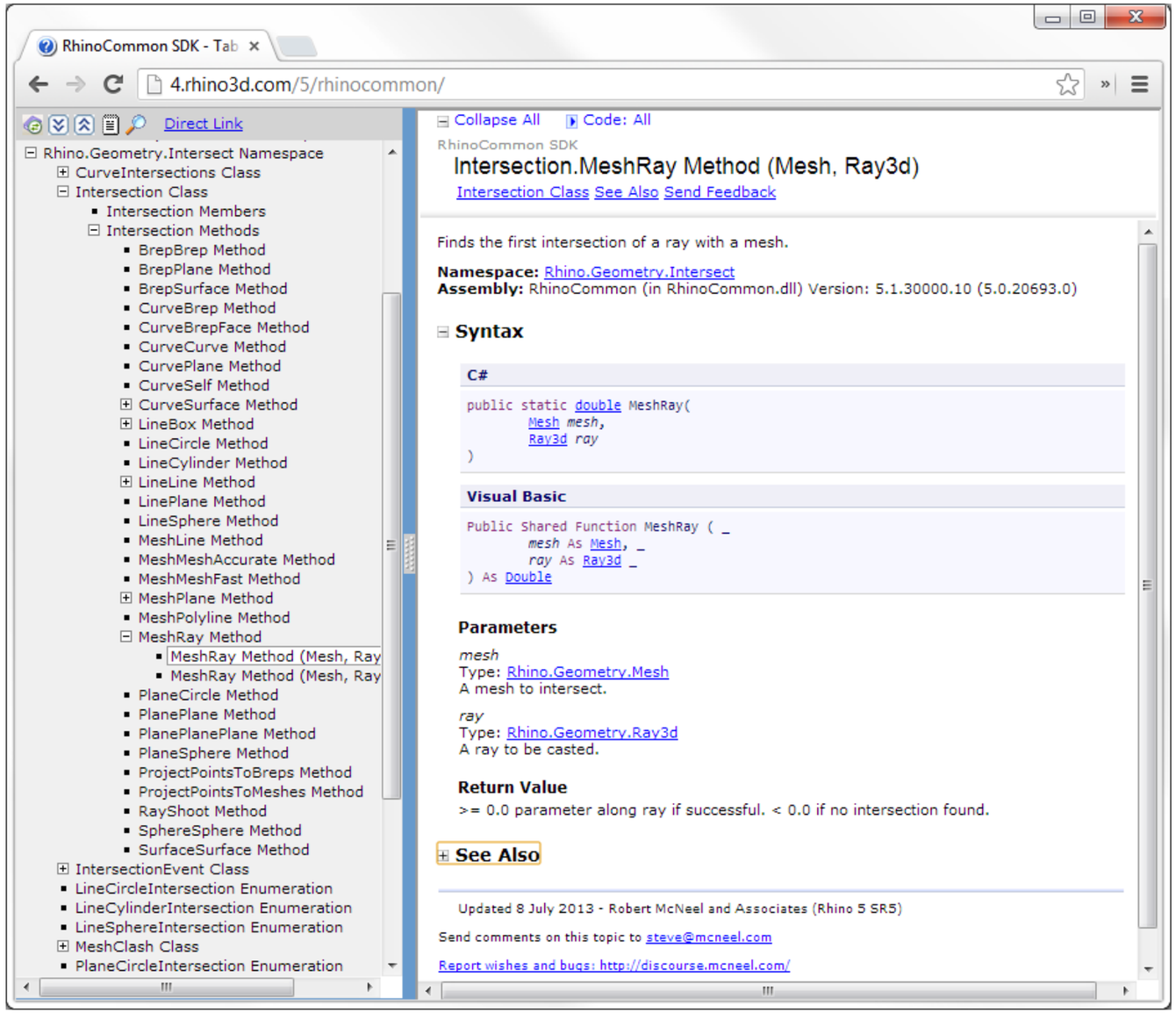
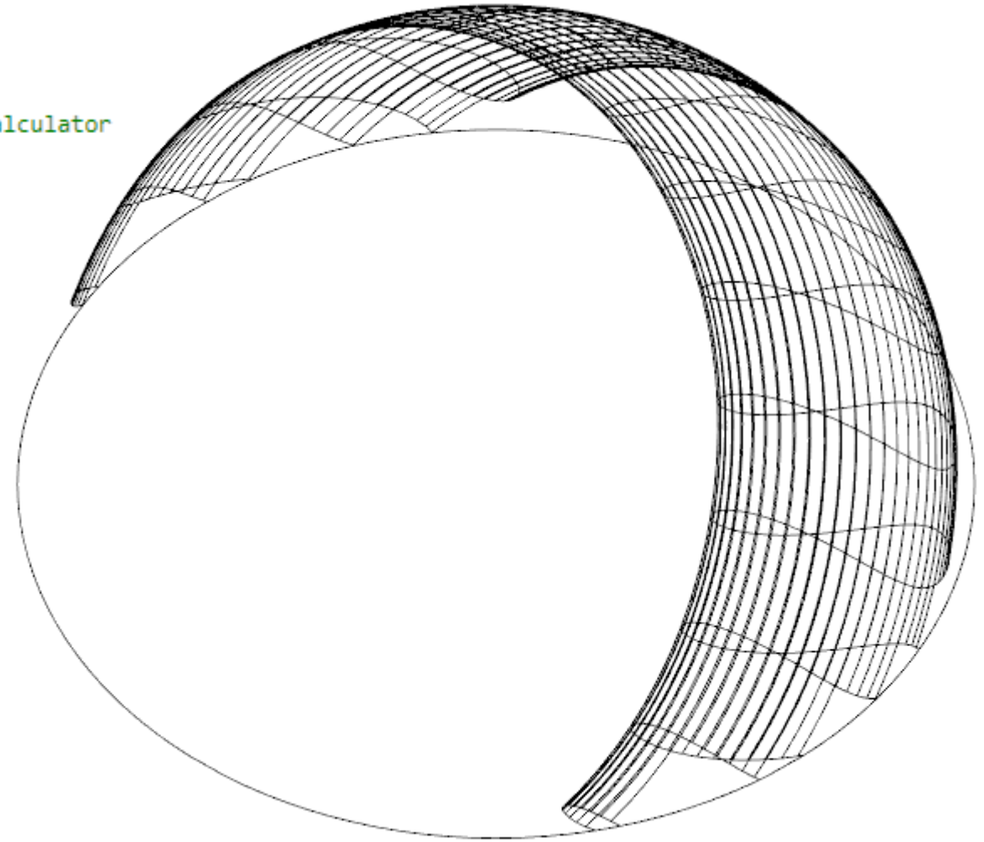


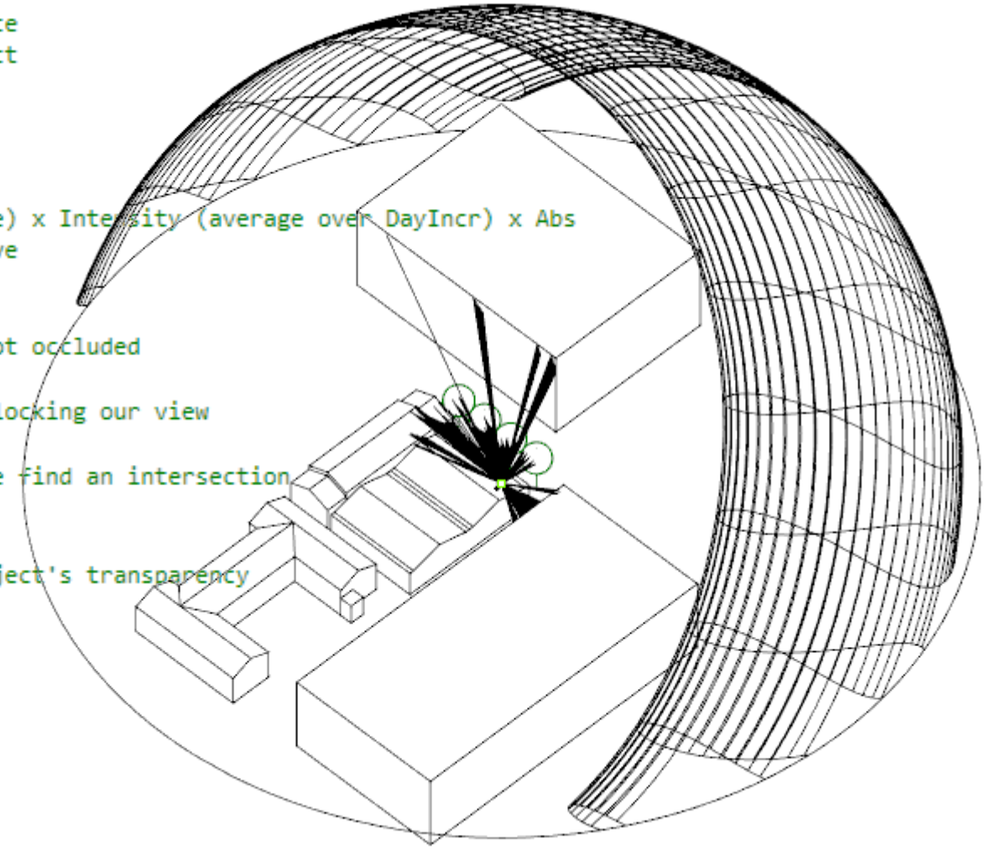
```
Dim SolarVec As Vector3d
For i As Integer = 0 To Days.Count - 1
    For j As Integer = 0 To Times.Count - 1
        SolarVec = CalcSolarVec(Days(i), Times(j), NAng, Latitude, Longitude, TimeZone) 'NREL Calculator
        Dim gline As New Line(New Point3d(0, 0, 1), SolarVec, 1)
        Dim xyplane As New Plane(New Point3d(0, 0, 0), New Vector3d(0, 0, 1))
        Dim param As Double
        If Rhino.Geometry.Intersect.Intersection.LinePlane(gline, xyplane, param) Then
            _Gpt.Add(gline.PointAt(param))
        End If
        _D.Add(Days(i))
        _T.Add(Times(j))
        _Index.Add(Math.Round(24 * (Days(i) - 1) + Times(j) - 1))
        _uv.Add(New Vector3d(i / (Days.Count - 1), j / (Times.Count - 1), 0))
        _Vec.Add(SolarVec)
        If SolarVec.Z >= 0 Then
            _Day.Add(True)
        Else
            _Day.Add(False)
        End If
    Next
Next
```



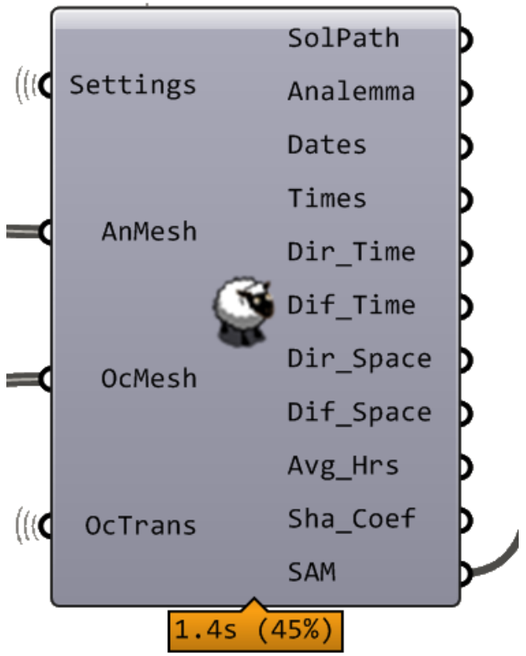
Urban Shading Losses Imported from Rhinoceros 3D

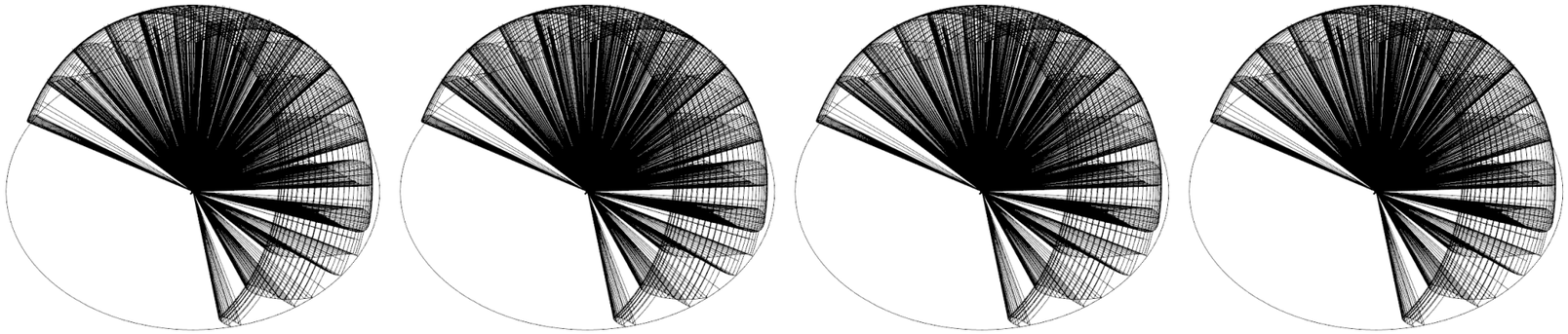
NREL Solar Calculator Code Snippet

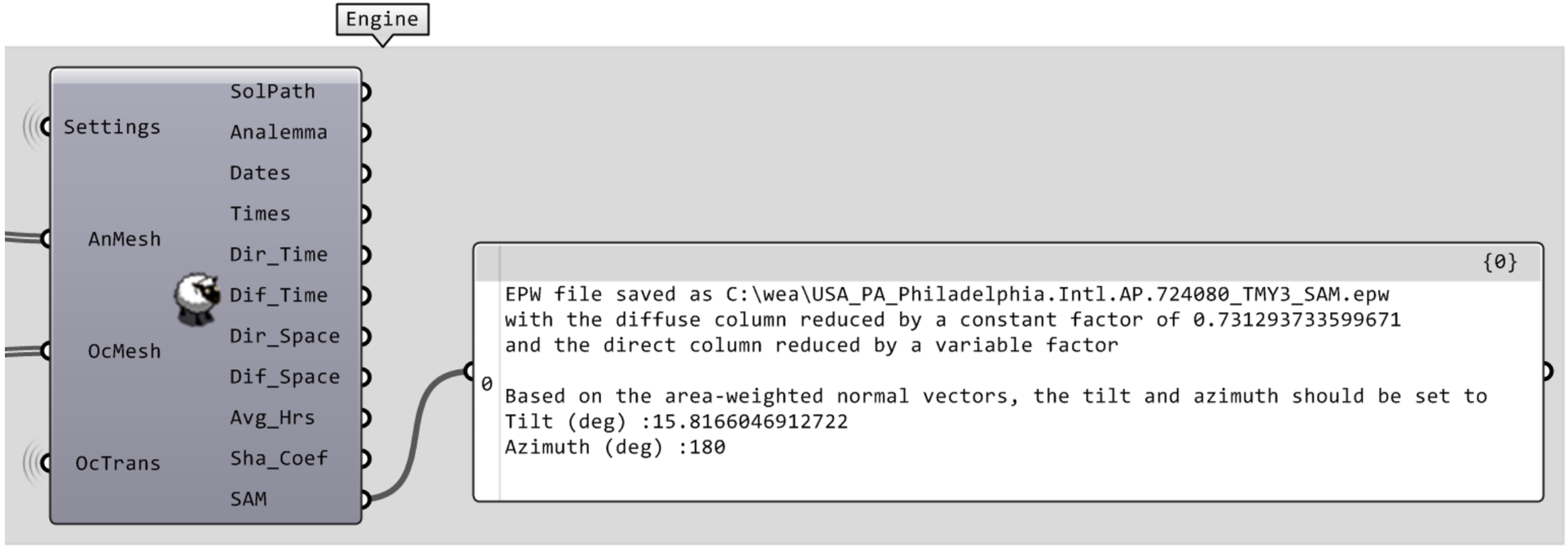
```
subtot = Vector3d.VectorAngle(_Vec(i), n_j(j))      'Check the angle between the sun and the face
If (subtot > Math.PI / 2) Then                      'If the sun's hitting the back face of object
    subtot = 0                                      'then ignore it.
    insun = 0
    percvissun = 0
Else                                                'Otherwise set the energy to
    subtot = Math.Cos(subtot) * CalcAvgRad(_dnr, _Index(i), DayIncr) * 1 'Cos(angle of incidence) x Intensity (average over DayIncr) x Abs
    If (subtot <= 0) Then                           'Check to make sure we're not in the negative
        subtot = 0
    End If
    If (insun = 1) Then                             'If we're still getting light, then we're not occluded
        Dim r As New Ray3d(P_j(j), _Vec(i))         'So look at the sun
        For k As Integer = 0 To OcMesh.Count - 1    'and see if any of the context meshses is blocking our view
            If OcTrans(k) < 1 Then                  'Ignore transparent meshes
                If (Rhino.Geometry.Intersect.Intersection.MeshRay(OcMesh(k), r) > 0) Then 'If we find an intersection
                    percvissun = percvissun * OcTrans(k)
                    insun = insun * OcTrans(k)
                    subtot = subtot * OcTrans(k)    'then scale energy down by the occluding object's transparency
                    If percvissun = 0 Then              'If we're fully occluded
                        k = OcMesh.Count - 1        'then don't bother looking any further
                    End If
                End If
            End If
        Next
    End If
End If
```



```
Select Case Parall
    Case "Enabled" 'Multithreading enabled
        Try
            Parallel.For(0, P_j.Count, AddressOf calcIncidentRadiationFactor)
        Catch ex As Exception
            errorcount += 1
            errormessage = ex.Message
        End Try
    Case "Disabled" 'Multithreading disabled
        For j As Integer = 0 To P_j.Count - 1
            calcIncidentRadiationFactor(j)
        Next
End Select
```

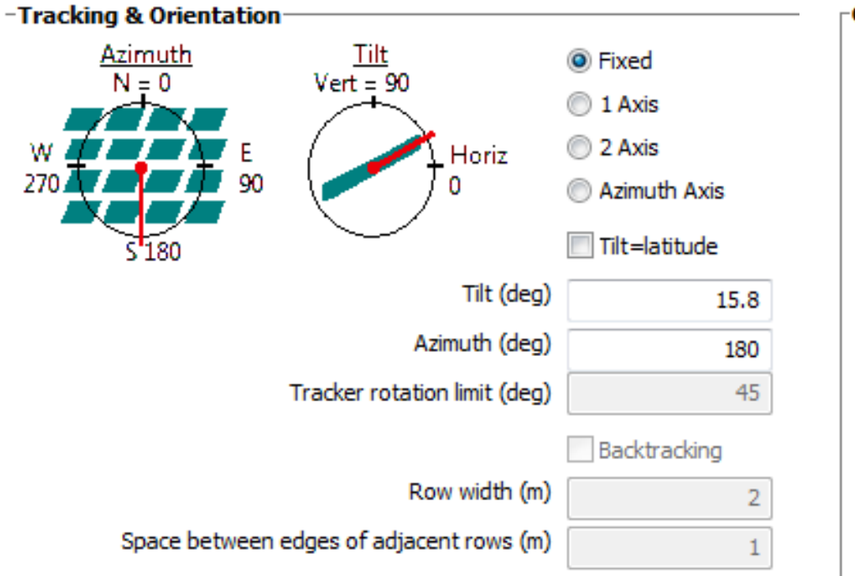


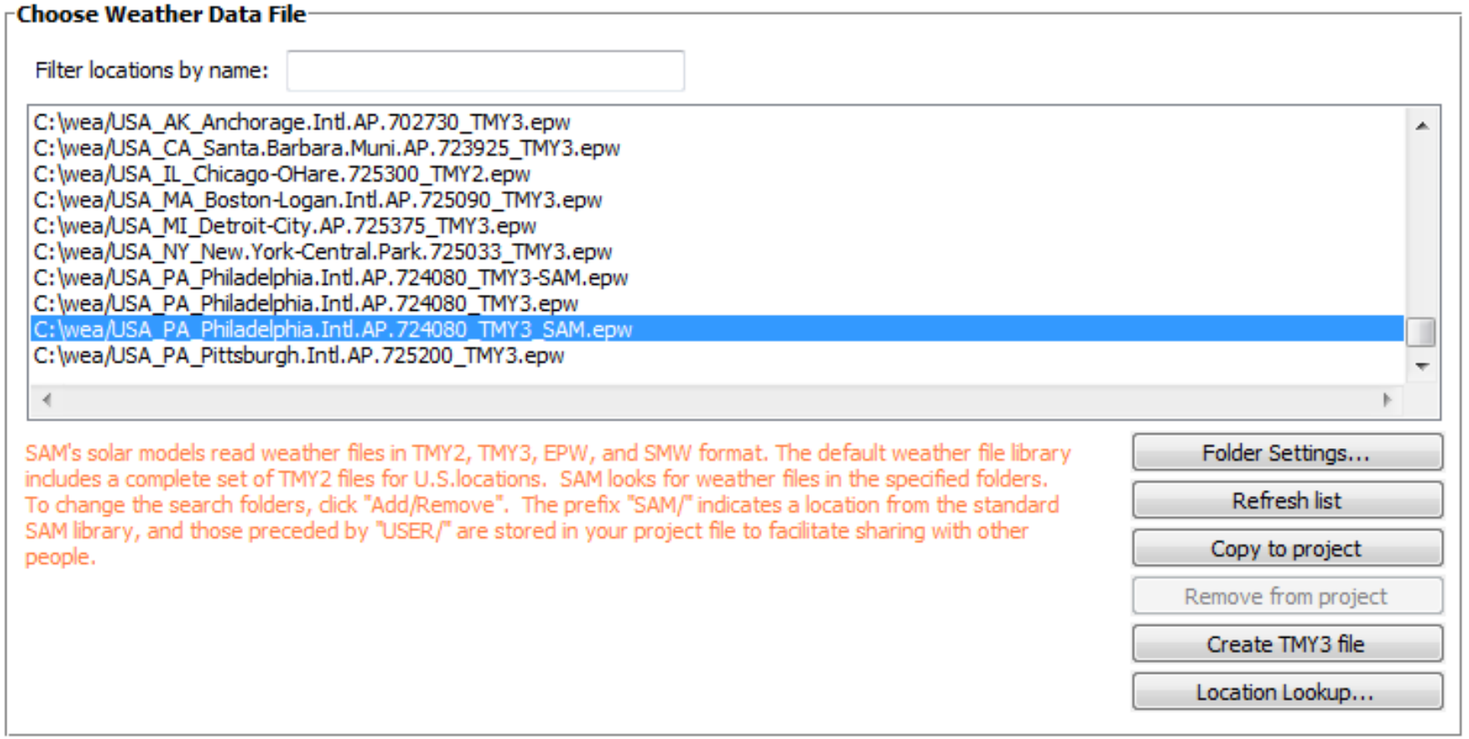


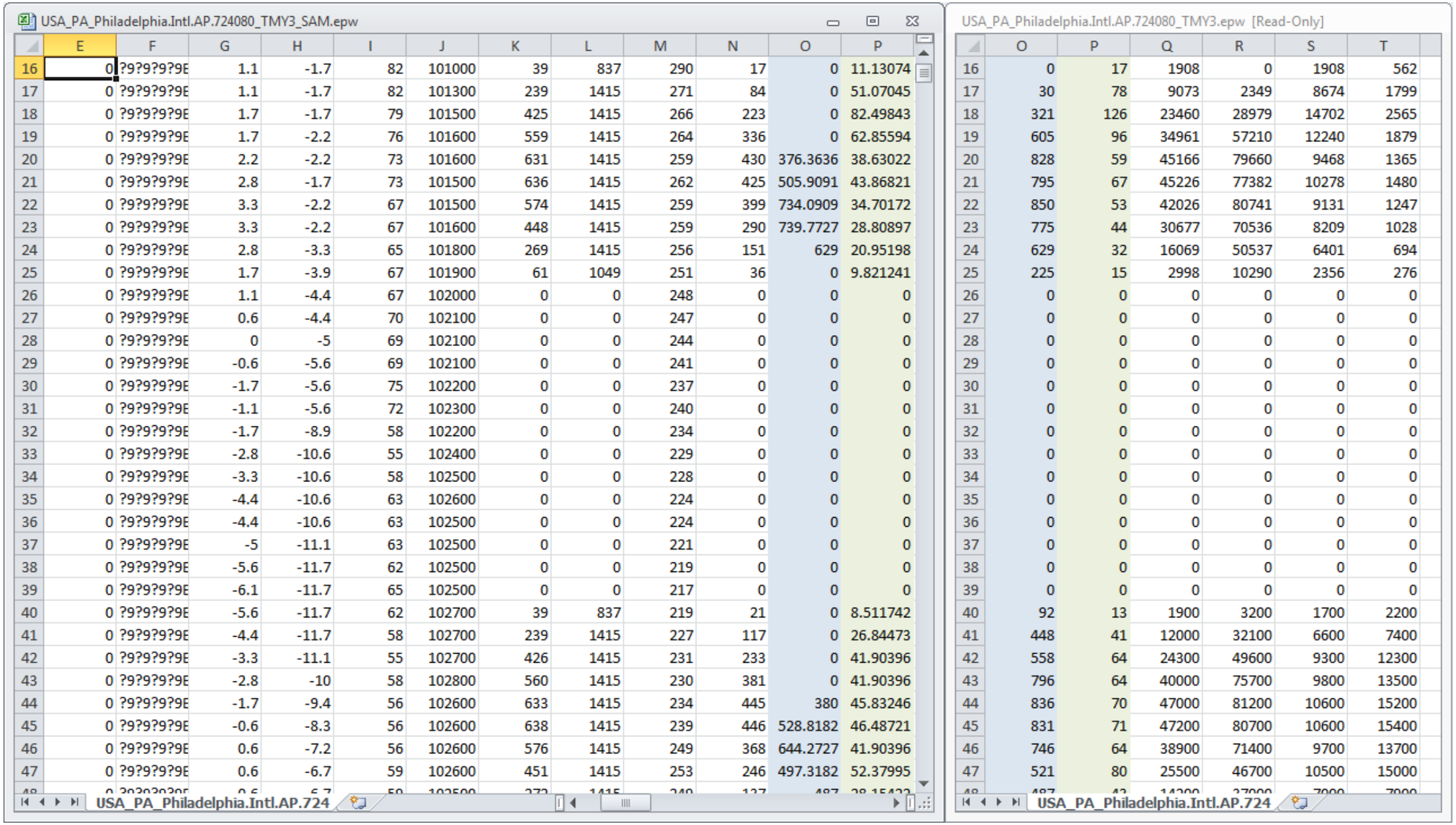


Urban Shading Losses Imported from Rhinoceros 3D

Modified .epw and input parameters for SAM







USA_PA_Philadelphia.Intl.AP.724080_TMY3_SAM.epw

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17	0	?9?9?9?9E	1.1	-1.7	82	101300	239	1415	271	84	0	51.07045
18	0	?9?9?9?9E	1.7	-1.7	79	101500	425	1415	266	223	0	82.49843
19	0	?9?9?9?9E	1.7	-2.2	76	101600	559	1415	264	336	0	62.85594
20	0	?9?9?9?9E	2.2	-2.2	73	101600	631	1415	259	430	376.3636	38.63022
21	0	?9?9?9?9E	2.8	-1.7	73	101500	636	1415	262	425	505.9091	43.86821
22	0	?9?9?9?9E	3.3	-2.2	67	101500	574	1415	259	399	734.0909	34.70172
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31	0	?9?9?9?9E	-1.1	-5.6	72	102300	0	0	240	0	0	0
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35	0	?9?9?9?9E	-4.4	-10.6	63	102600	0	0	224	0	0	0
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37	0	?9?9?9?9E	-5	-11.1	63	102500	0	0	221	0	0	0
38	0	?9?9?9?9E	-5.6	-11.7	62	102500	0	0	219	0	0	0
39	0	?9?9?9?9E	-6.1	-11.7	65	102500	0	0	217	0	0	0
40	0	?9?9?9?9E	-5.6	-11.7	62	102700	39	837	219	21	0	8.511742
41	0	?9?9?9?9E	-4.4	-11.7	58	102700	239	1415	227	117	0	26.84473
42	0	?9?9?9?9E	-3.3	-11.1	55	102700	426	1415	231	233	0	41.90396
43	0	?9?9?9?9E	-2.8	-10	58	102800	560	1415	230	381	0	41.90396
44	0	?9?9?9?9E	-1.7	-9.4	56	102600	633	1415	234	445	380	45.83246
45	0	?9?9?9?9E	-0.6	-8.3	56	102600	638	1415	239	446	528.8182	46.48721
46	0	?9?9?9?9E	0.6	-7.2	56	102600	576	1415	249	368	644.2727	41.90396
47	0	?9?9?9?9E	0.6	-6.7	59	102600	451	1415	253	246	497.3182	52.37995

USA_PA_Philadelphia.Intl.AP.724

USA_PA_Philadelphia.Intl.AP.724080_TMY3.epw [Read-Only]

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17	30	78	9073	2349	8674	1799
18	321	126	23460	28979	14702	2565
19	605	96	34961	57210	12240	1879
20	828	59	45166	79660	9468	1365
21	795	67	45226	77382	10278	1480
22	850	53	42026	80741	9131	1247
23	775	44	30677	70536	8209	1028
24	629	32	16069	50537	6401	694
25	225	15	2998	10290	2356	276
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	92	13	1900	3200	1700	2200
41	448	41	12000	32100	6600	7400
42	558	64	24300	49600	9300	12300
43	796	64	40000	75700	9800	13500
44	836	70	47000	81200	10600	15200
45	831	71	47200	80700	10600	15400
46	746	64	38900	71400	9700	13700
47	521	80	25500	46700	10500	15000

USA_PA_Philadelphia.Intl.AP.724

Urban Shading Losses Imported from Rhinoceros 3D

Modification to Beam and Diffuse Columns

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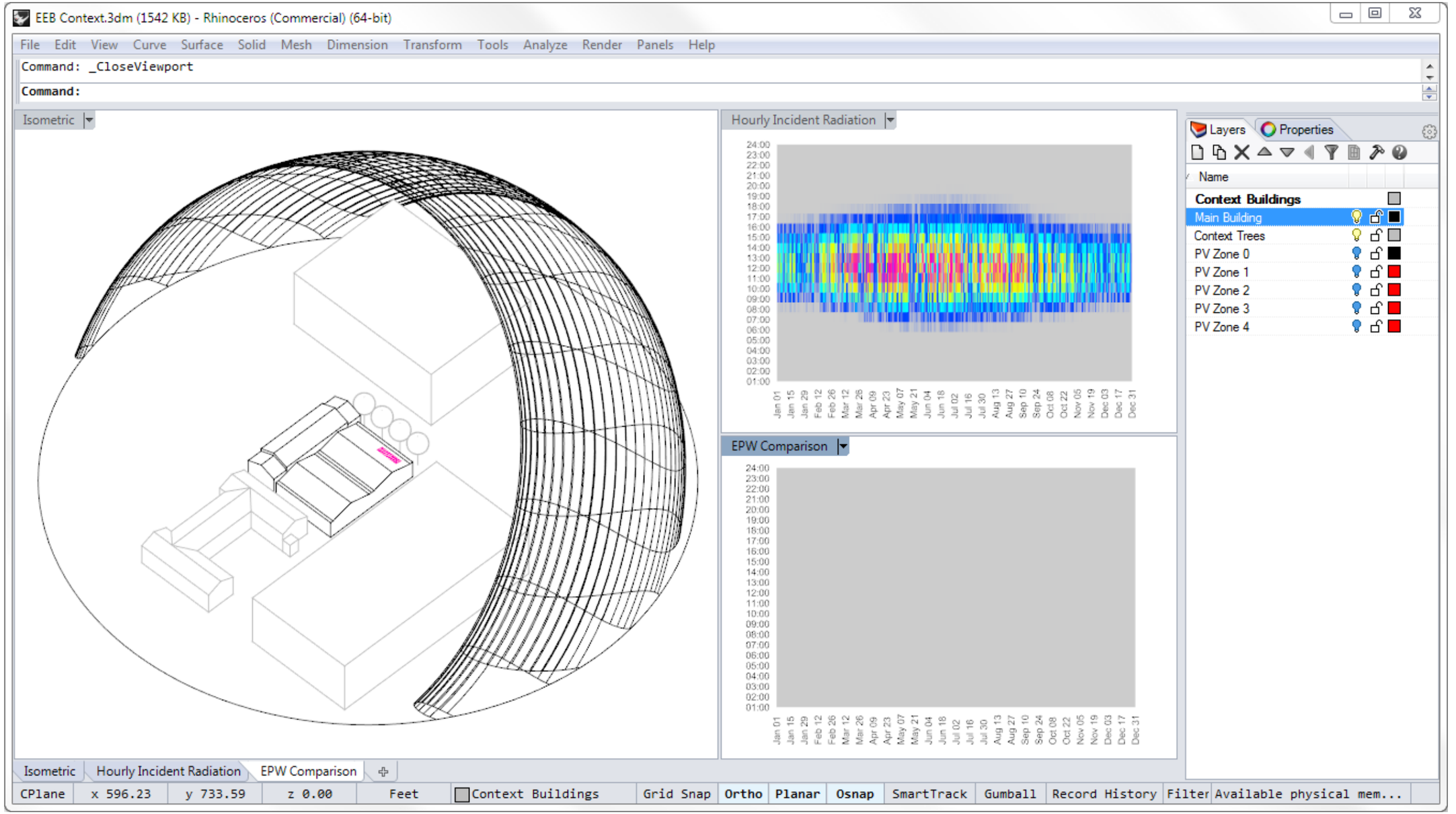
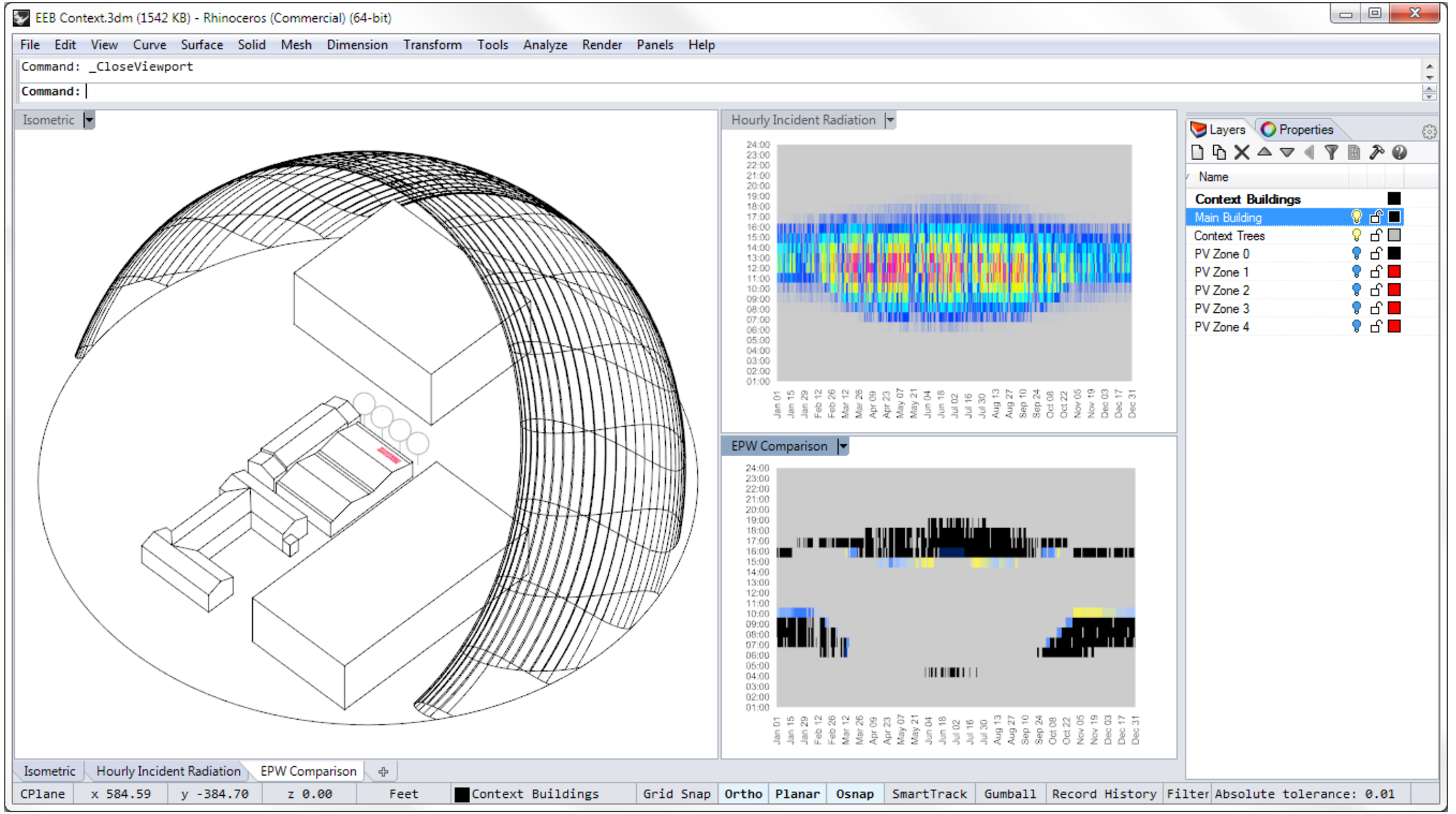


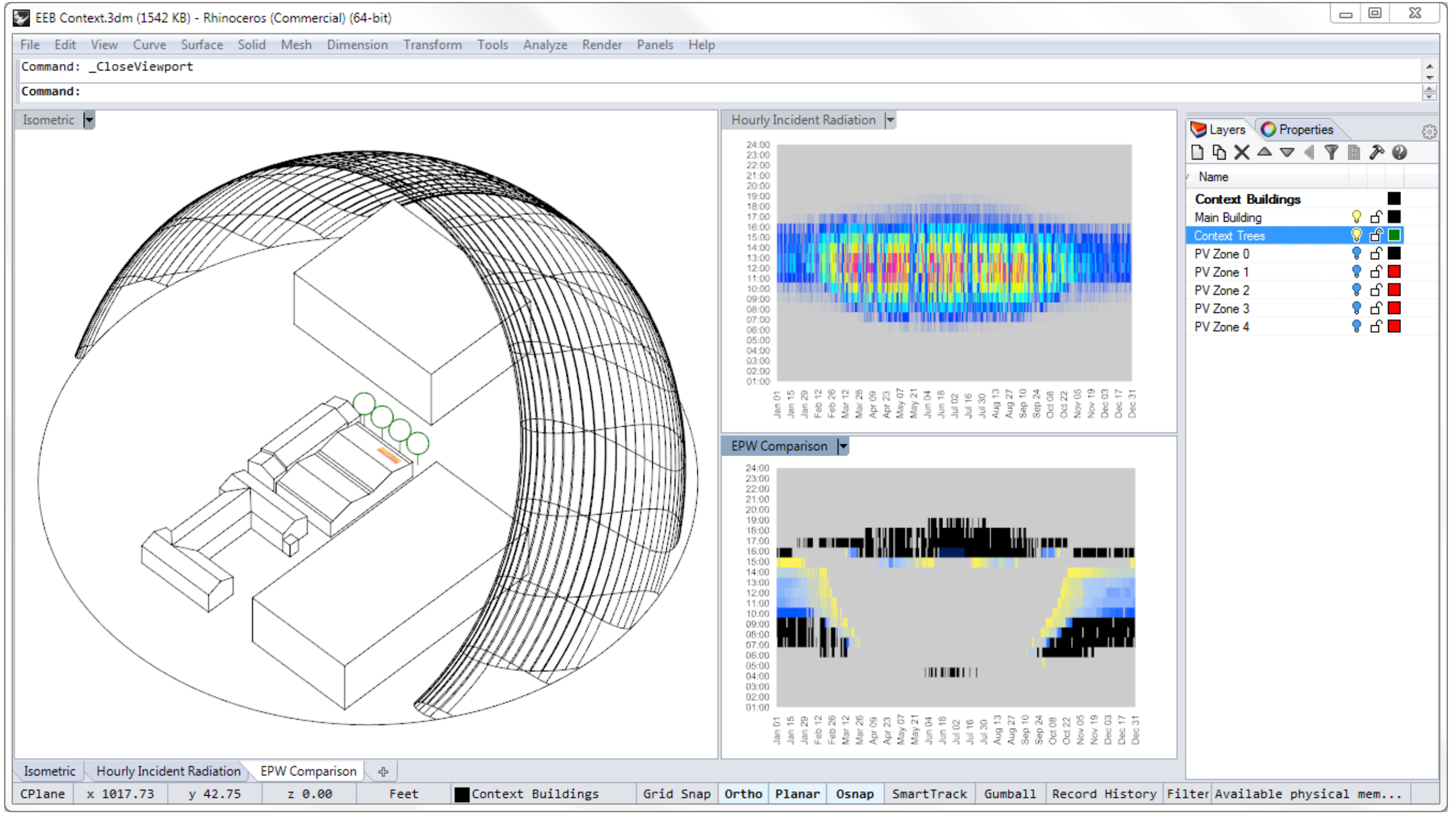
Urban Shading Losses Imported from Rhinoceros 3D

No Shading - PV Zone 1



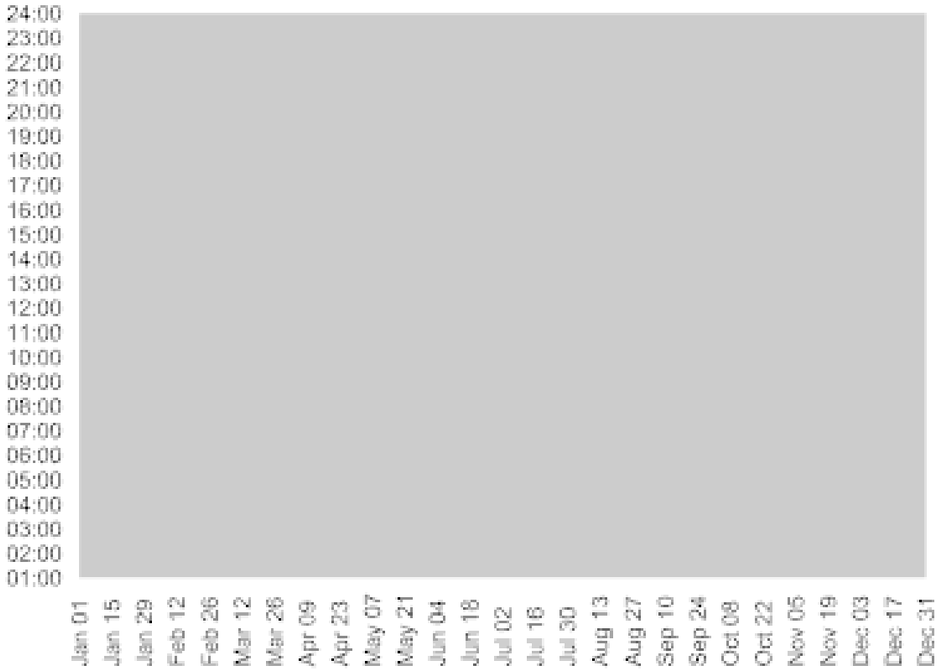
Urban Shading Losses Imported from Rhinoceros 3D

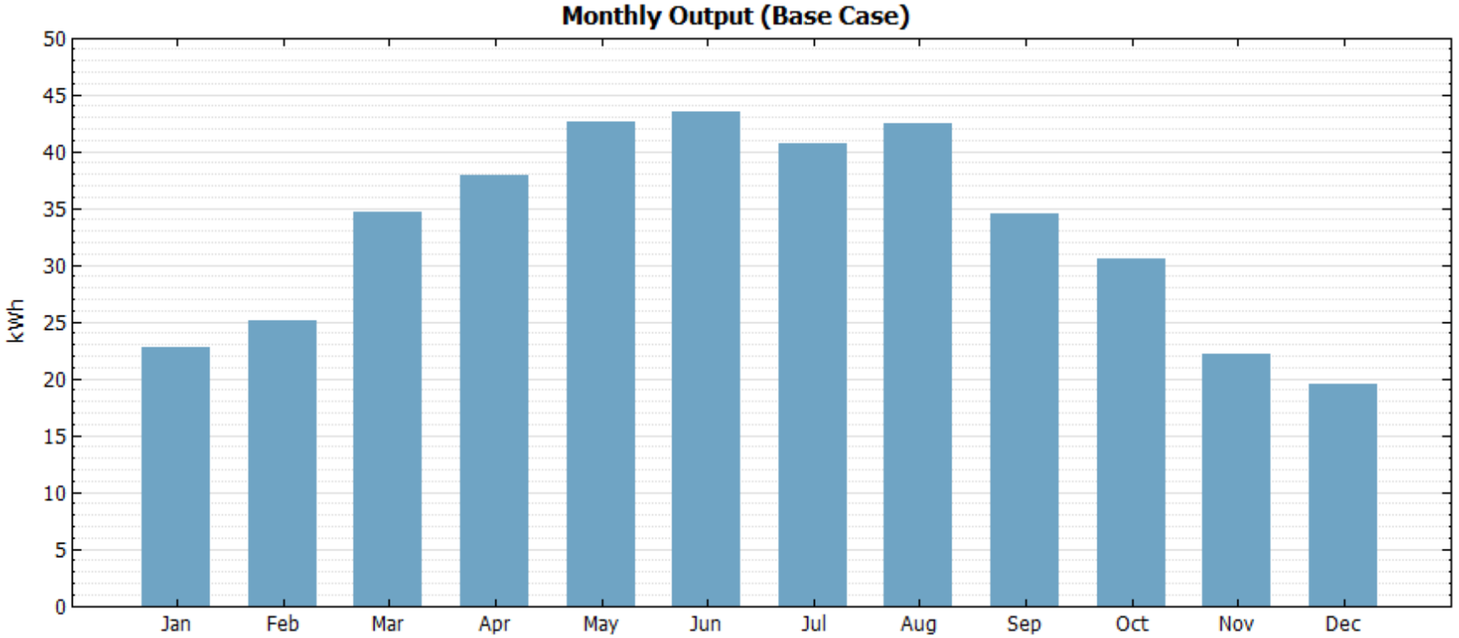
Building Shading Context - PV Zone 1



Urban Shading Losses Imported from Rhinoceros 3D

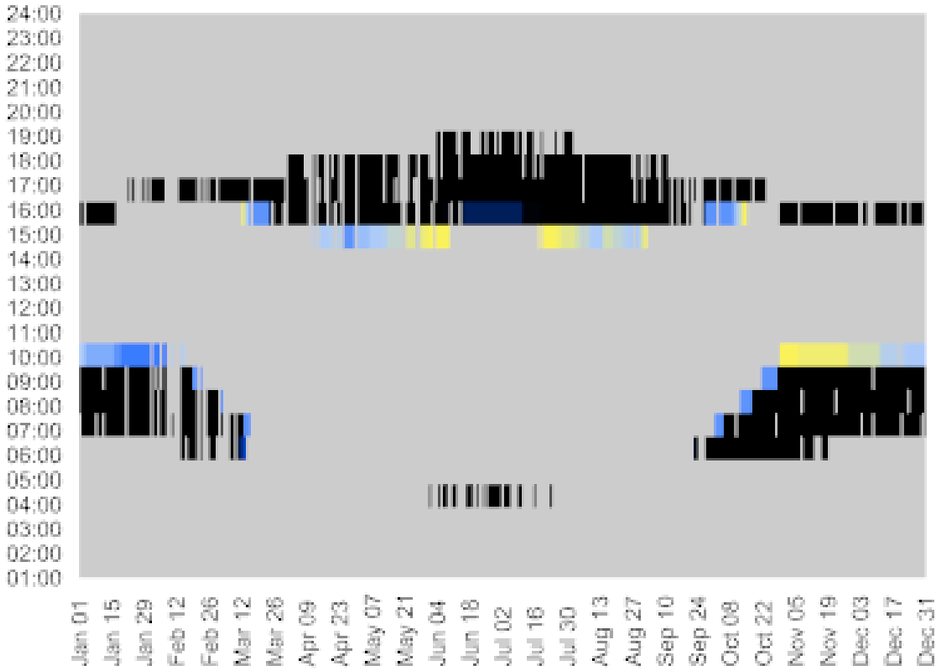
Vegetative and Building Shading Context - PV Zone 1

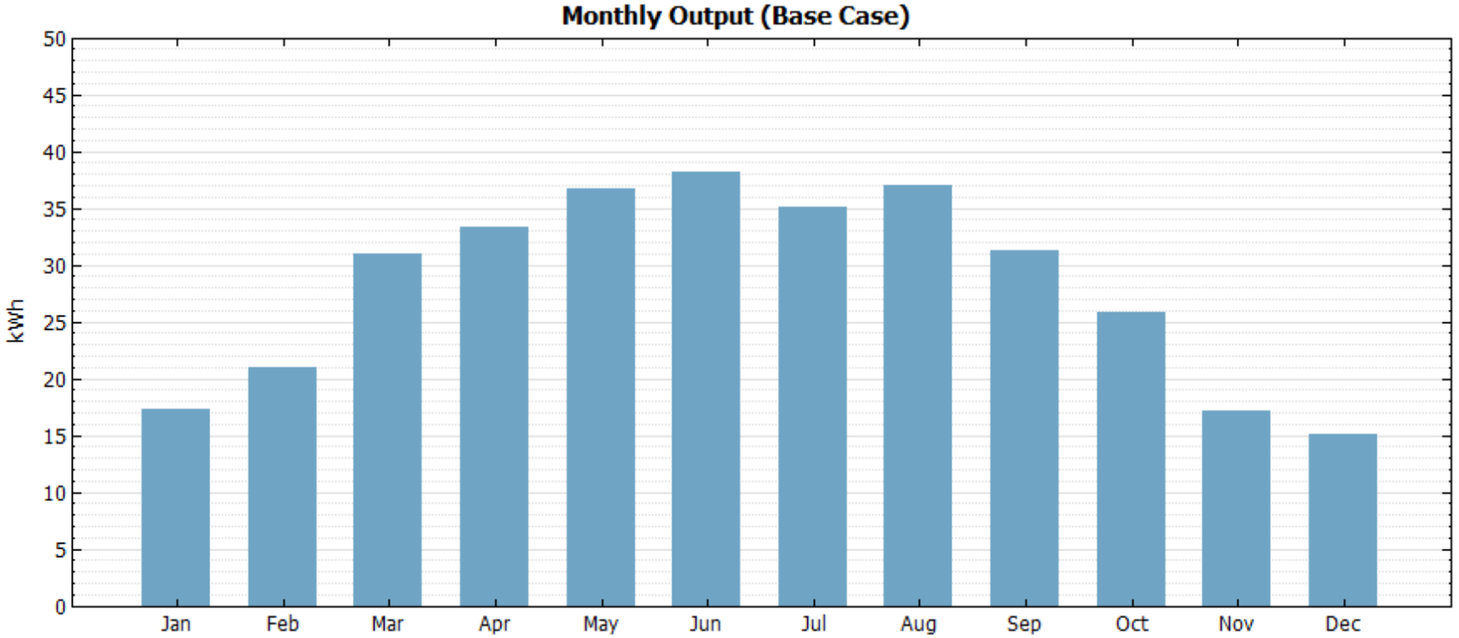




Urban Shading Losses Imported from Rhinoceros 3D

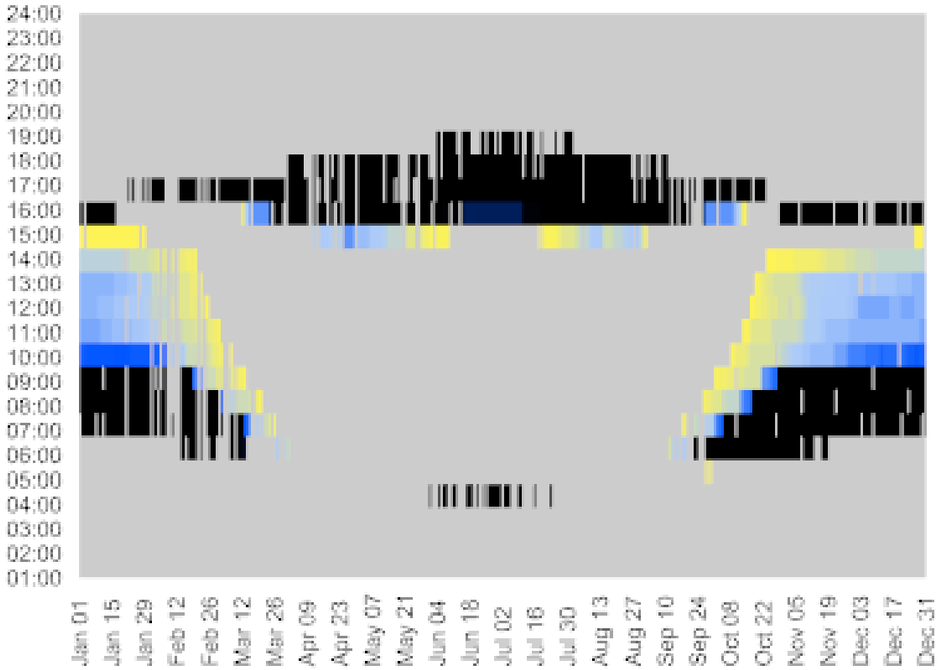
No Shading - PV Zone 1

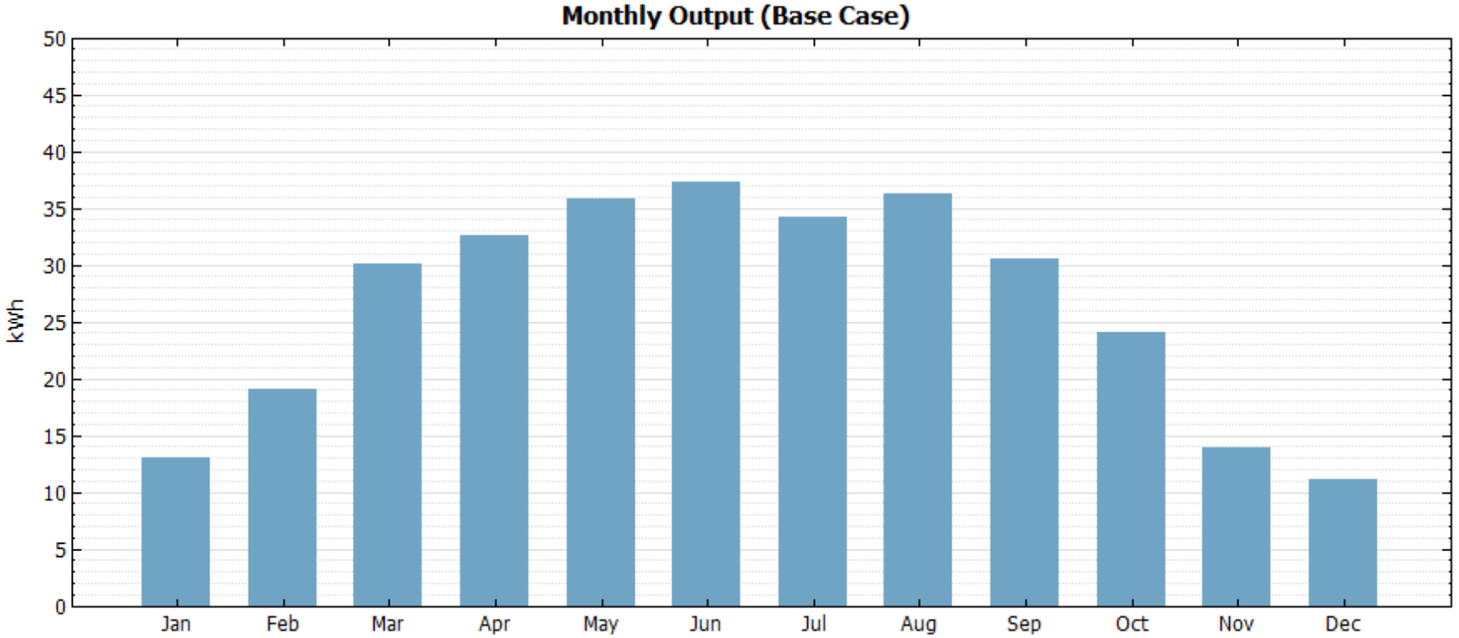




Urban Shading Losses Imported from Rhinoceros 3D

Building Shading Context - PV Zone 1



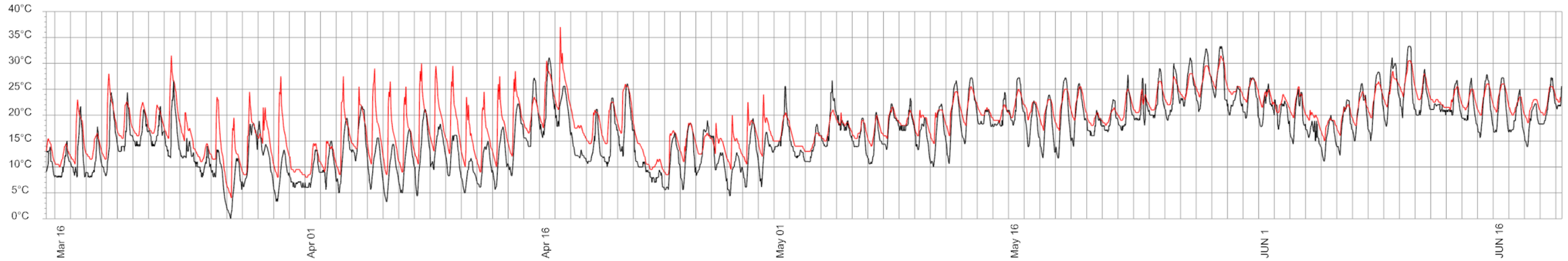


Urban Shading Losses Imported from Rhinoceros 3D

No Shading Context				
	Zone 1	Zone 2	Zone 3	Zone 4
Jan	21.9831	21.9831	21.9831	21.9831
Feb	24.3661	24.3661	24.3661	24.3661
Mar	33.4428	33.4428	33.4428	33.4428
Apr	36.6999	36.6999	36.6999	36.6999
May	41.2011	41.2011	41.2011	41.2011
Jun	41.9813	41.9813	41.9813	41.9813
Jul	39.1858	39.1858	39.1858	39.1858
Aug	41.0817	41.0817	41.0817	41.0817
Sep	33.4444	33.4444	33.4444	33.4444
Oct	29.6094	29.6094	29.6094	29.6094
Nov	21.4378	21.4378	21.4378	21.4378
Dec	18.8721	18.8721	18.8721	18.8721
Total	383.306	383.306	383.306	383.306
	0%	0%	0%	0%

Buidling Shading Context				
	Zone 1	Zone 2	Zone 3	Zone 4
Jan	17.2592	13.2859	17.4879	19.3758
Feb	20.8842	20.1917	19.832	21.6968
Mar	30.9731	30.8675	28.0113	30.7064
Apr	33.2577	33.6159	32.1175	34.0641
May	36.6682	37.8604	36.2573	38.4315
Jun	38.1147	38.8702	37.7046	39.4359
Jul	35.1047	36.0235	34.6814	36.6077
Aug	37.0072	37.7681	36.3072	38.2926
Sep	31.2304	31.1084	29.535	31.1567
Oct	25.7814	25.5416	24.6506	26.7792
Nov	17.0691	14.1989	17.121	19.1635
Dec	15.0912	11.8092	14.9874	16.575
Total	338.441	331.141	328.693	352.285
	-12%	-14%	-14%	-8%

Building and Vegetative Shading Context				
	Zone 1	Zone 2	Zone 3	Zone 4
Jan	13.0813	9.33704	17.4537	19.3301
Feb	19.0622	18.0527	19.7993	21.6525
Mar	30.105	30.0403	27.9593	30.6337
Apr	32.6158	33.0202	32.0583	33.9811
May	35.8541	37.0992	36.1825	38.327
Jun	37.2994	38.1069	37.6287	39.3336
Jul	34.2565	35.228	34.602	36.5002
Aug	36.2619	37.068	36.2407	38.1942
Sep	30.5874	30.502	29.4846	31.0863
Oct	24.0711	23.6794	24.6069	26.7209
Nov	13.8344	10.8602	17.084	19.1148
Dec	11.1426	8.10128	14.9569	16.5356
Total	318.172	311.095	328.057	351.410
	-17%	-19%	-14%	-8%



Urban Shading Losses Imported from Rhinoceros 3D

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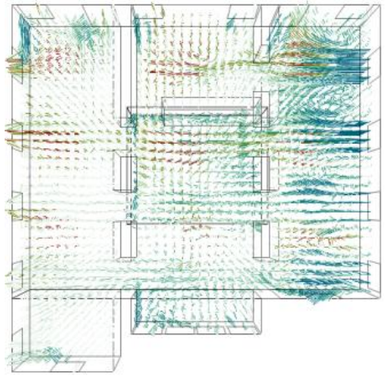
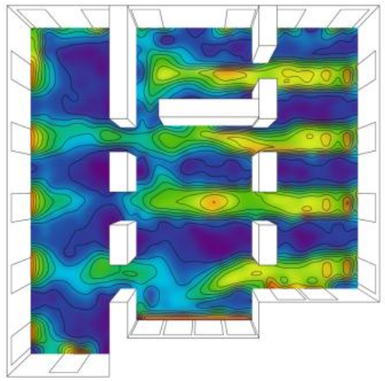
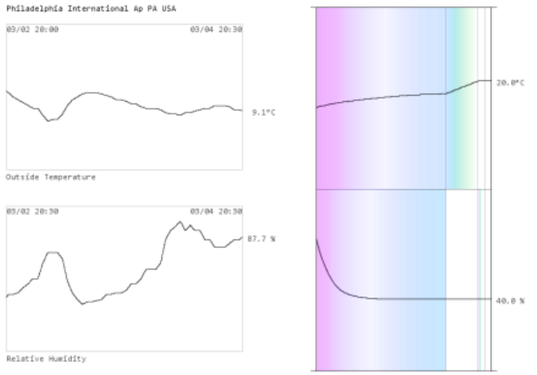
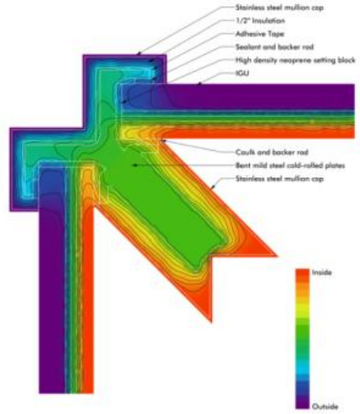
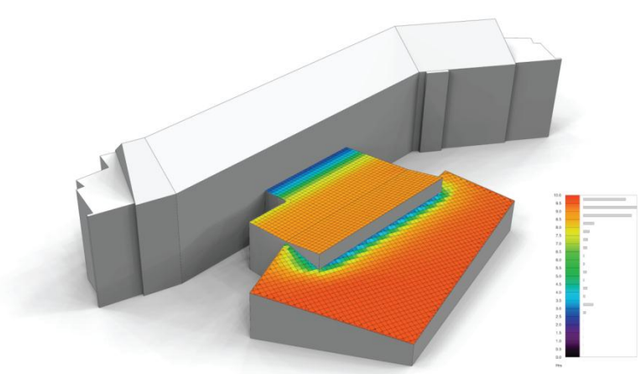
Next Steps – Variable Shading Coefficients, Temperature Corrections

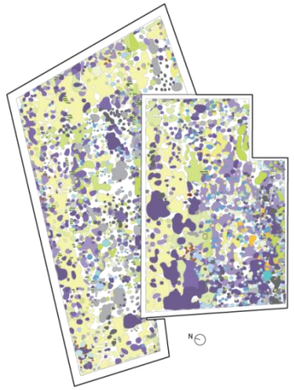


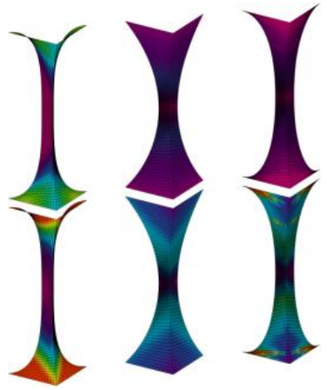


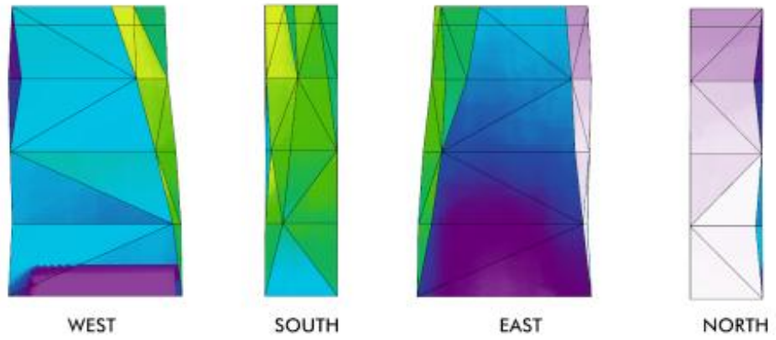


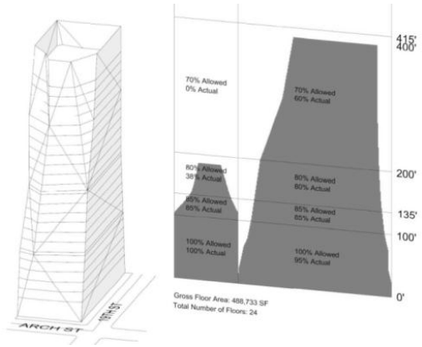


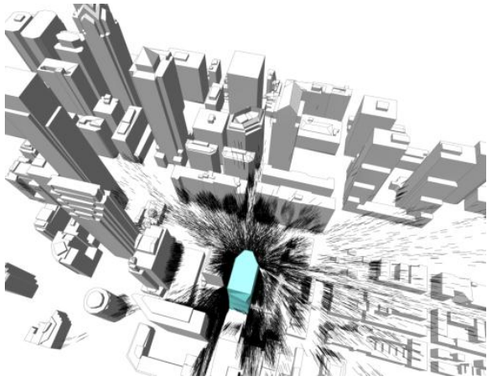












Urban Shading Losses Imported from Rhinoceros 3D

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Why do we model?